Ch. 3

MULTIVIBRATORS

Dr. Mohamed Salah

Multivibrator

Is an electronic circuit that switches rapidly by means of positive feedback between two or more states.

Or

Is an electronic circuit used to implement a variety of simple two-state systems such as oscillators, timers and flip-flops.

There are three types of multivibrator circuits depending on the circuit operation

These multivibrators are distinguished by the type of stable logic state condition at their output

Multivibrators

Astable

Free-Running

In which the circuit is not stable in either state.
It continually switches from one state to the other.
It functions as a relaxation oscillator.

Monostable

One Shot

In which one of the states is stable, but the other state is unstable (transient).
A trigger pulse causes the circuit to enter the unstable state.

Bistable

Flip-Flop

In which the circuit is stable in either state.
It can be flipped from one state to the other by an external trigger pulse.
It can be used to store one bit of information.

Astable Multivibrators → Free-Running

It is called free-running because it alternates between two different output voltage levels during the time it is on.

The output remains at each voltage level for a definite period of time.

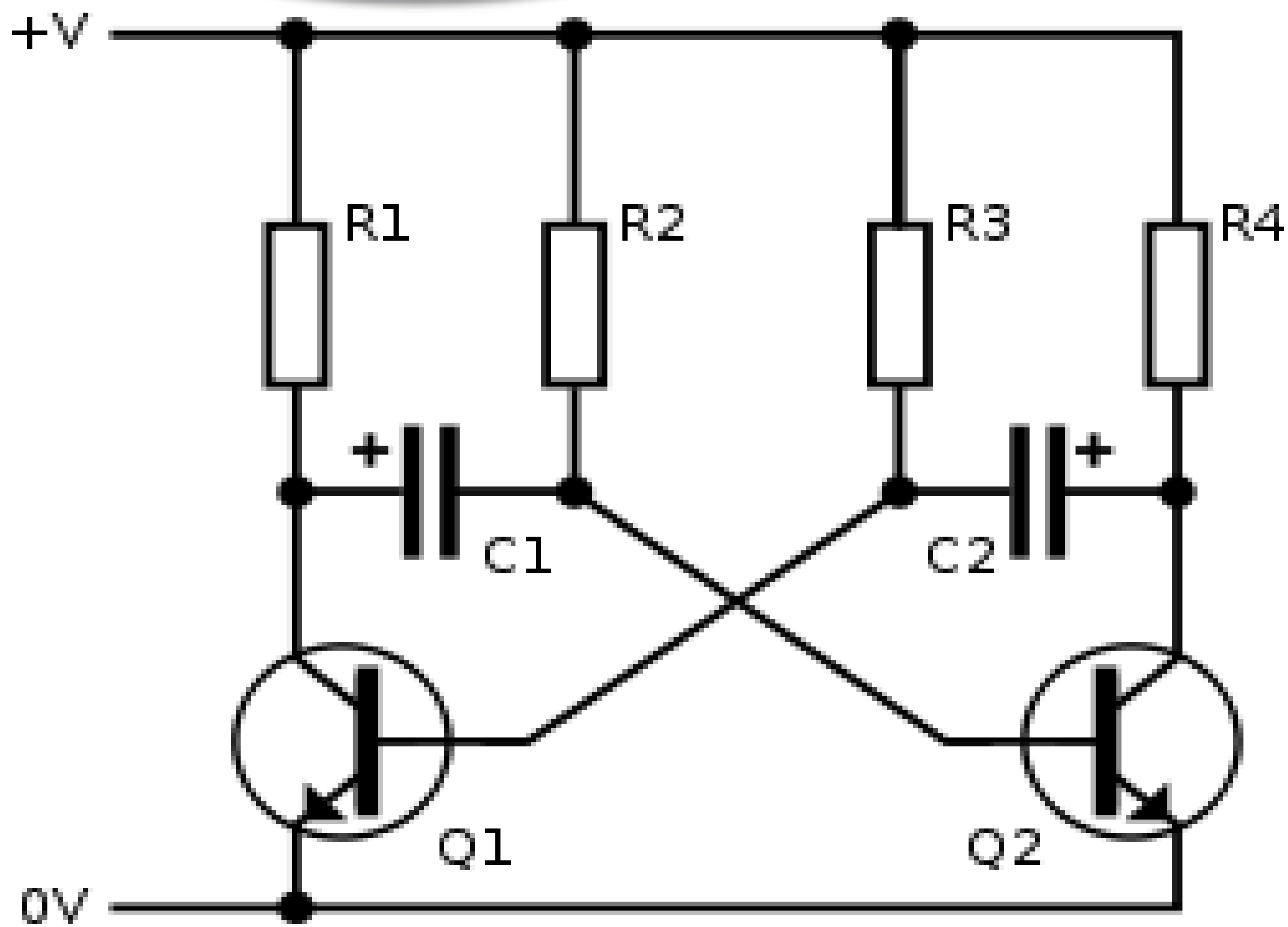
The astable multivibrator has two outputs, but NO inputs (just DC).

An astable multivibrator is a regenerative circuit consisting of two amplifying stages connected in a positive feedback loop by two capacitive-resistive coupling networks.

The amplifying elements may be junction or field-effect transistors, vacuum tubes, operational amplifiers, or other types of amplifier.

Astable Multivibrators

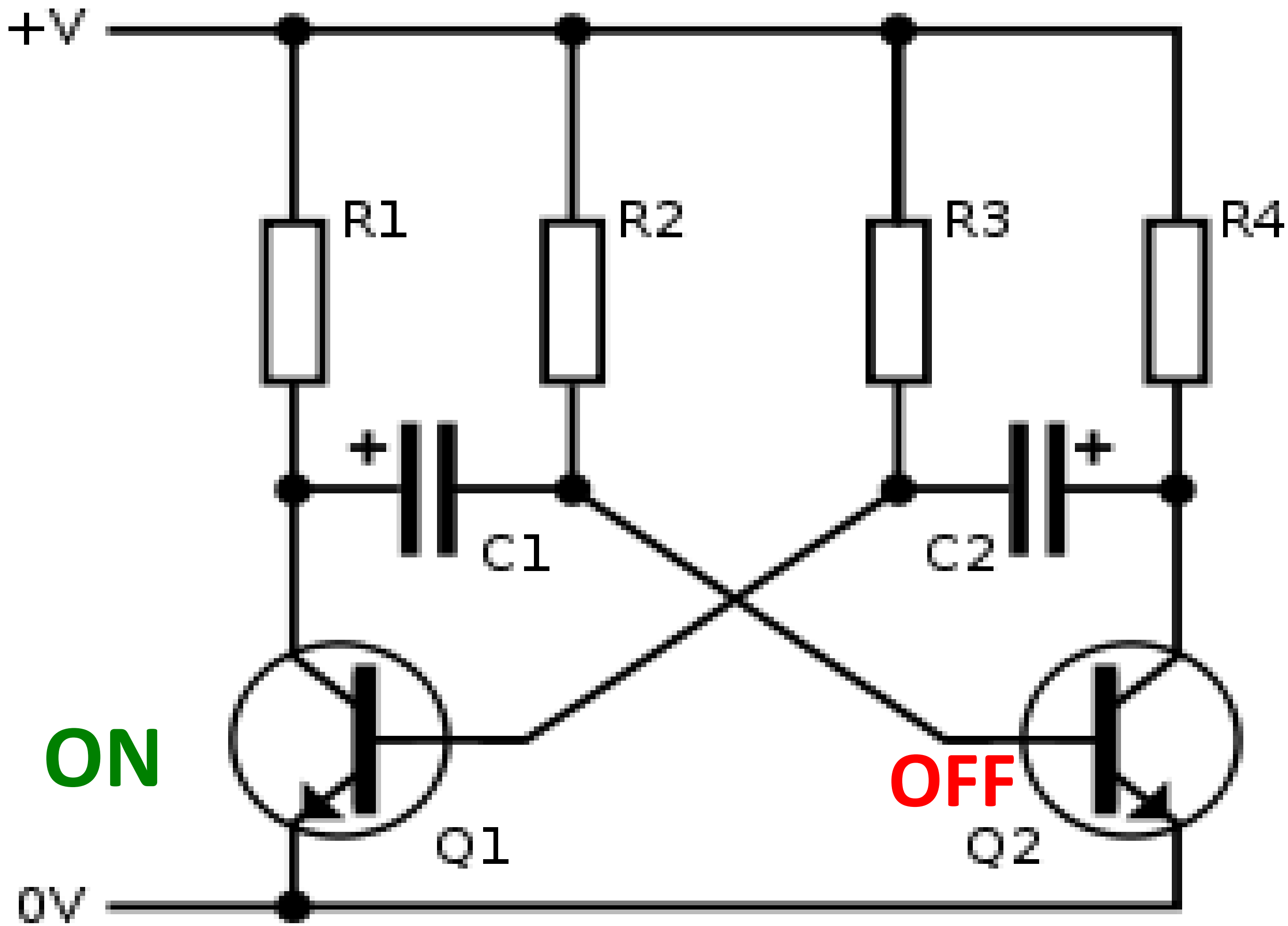
Two output terminals can be defined at the active devices, which will have complementary states; one will have high voltage while the other has low voltage, (except during the brief transitions from one state to the other).



Typically, $R_2 = R_3$, $R_1 = R_4$, $C_1 = C_2$ and $R_2 >> R_1$.

Operation

Astable Multivibrators



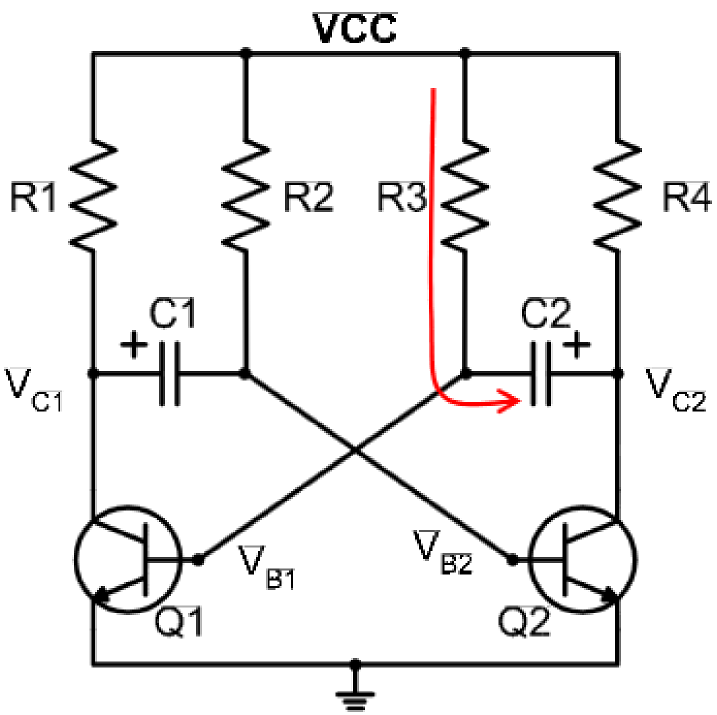
State 1

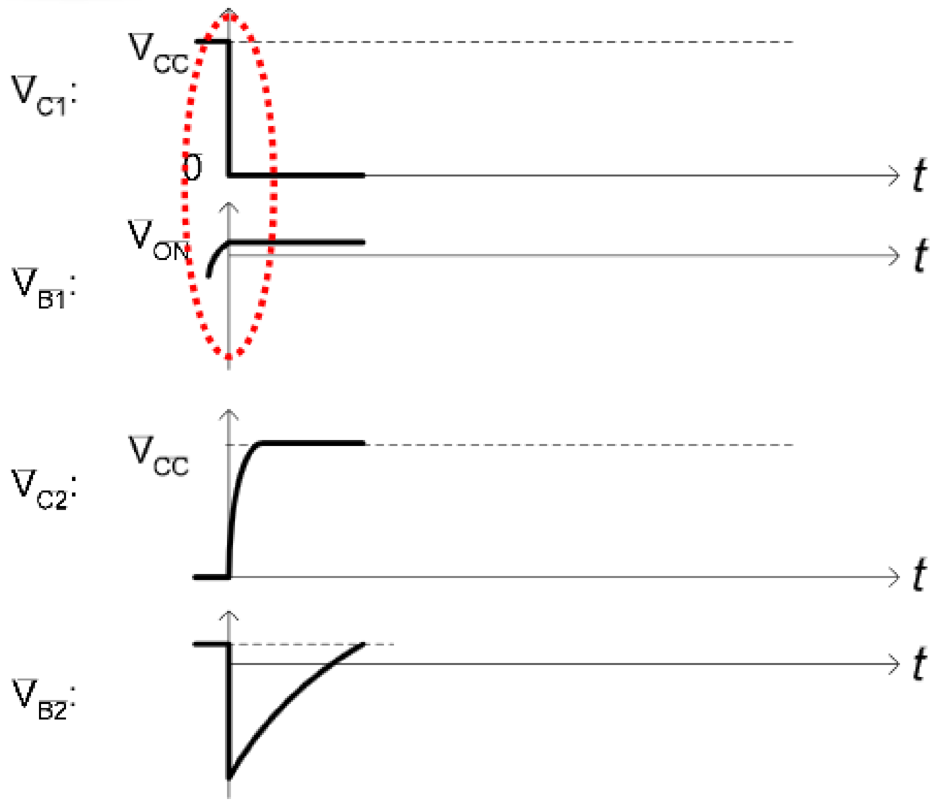
V_{C1} LOW, V_{C2} HIGH, Q_1 ON (saturation) and Q_2 OFF.

Operation

Astable Multivibrators

State 1





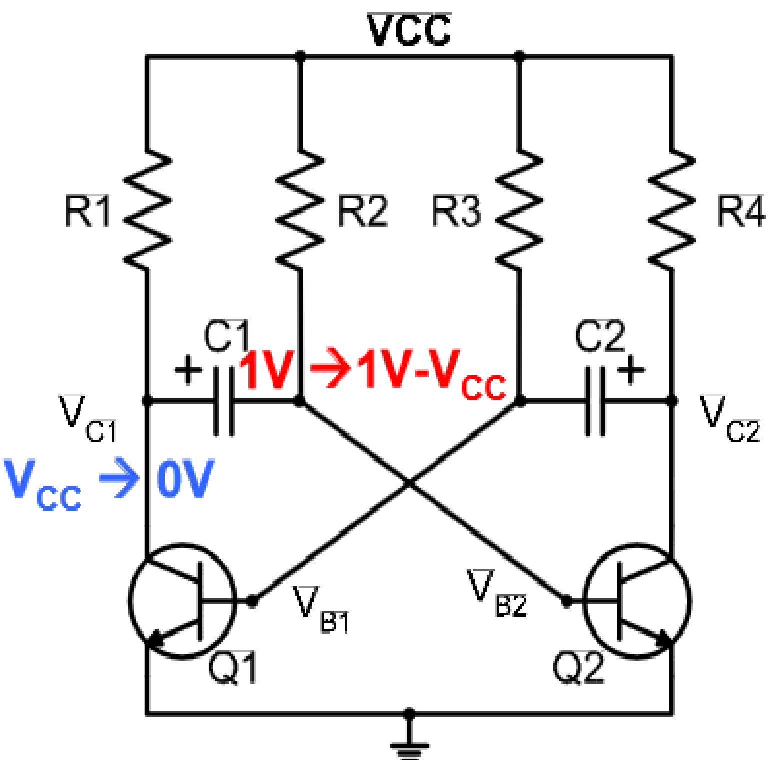
State 1:

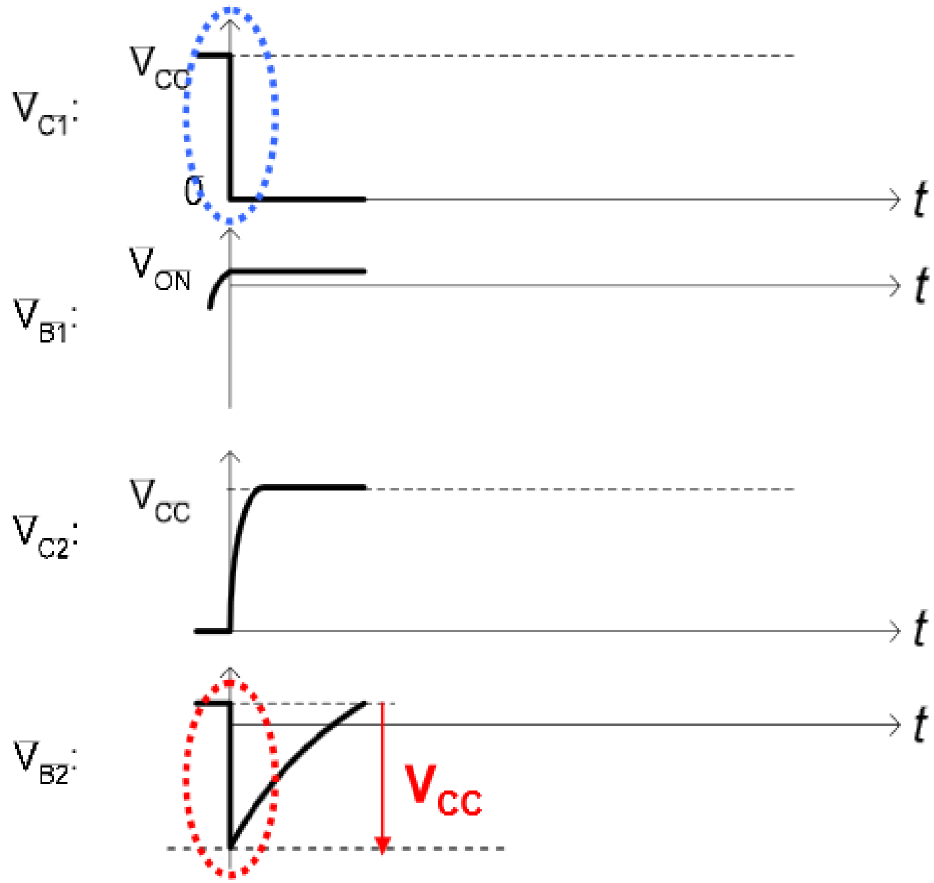
- V_{B1} charges up through R_3 from below ground towards V_{CC}.
- When V_{B1} reaches V_{ON} (of $V_{BE,}$ ≈1V), Q_1 turns on and pulls V_{C1} from V_{CC} to V_{CESat} ≈ 0V.

Operation

Astable Multivibrators

State 1





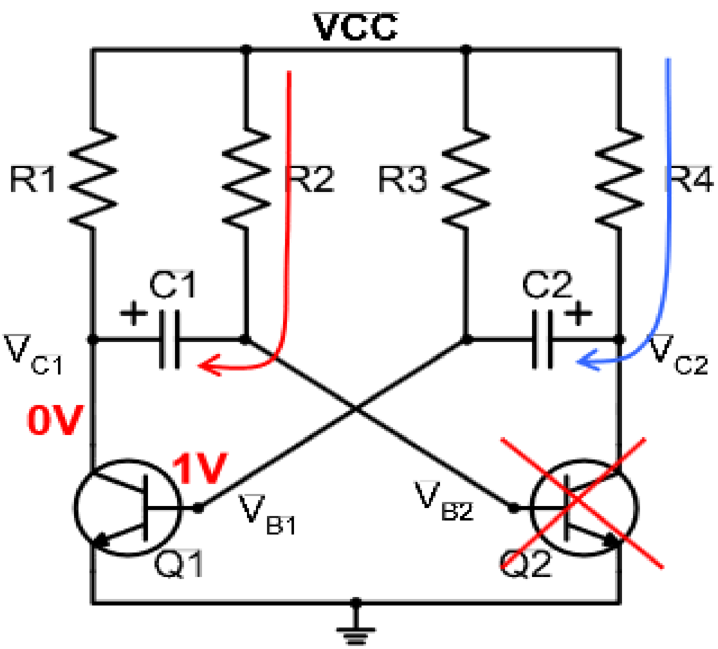
State 1 (cont'd):

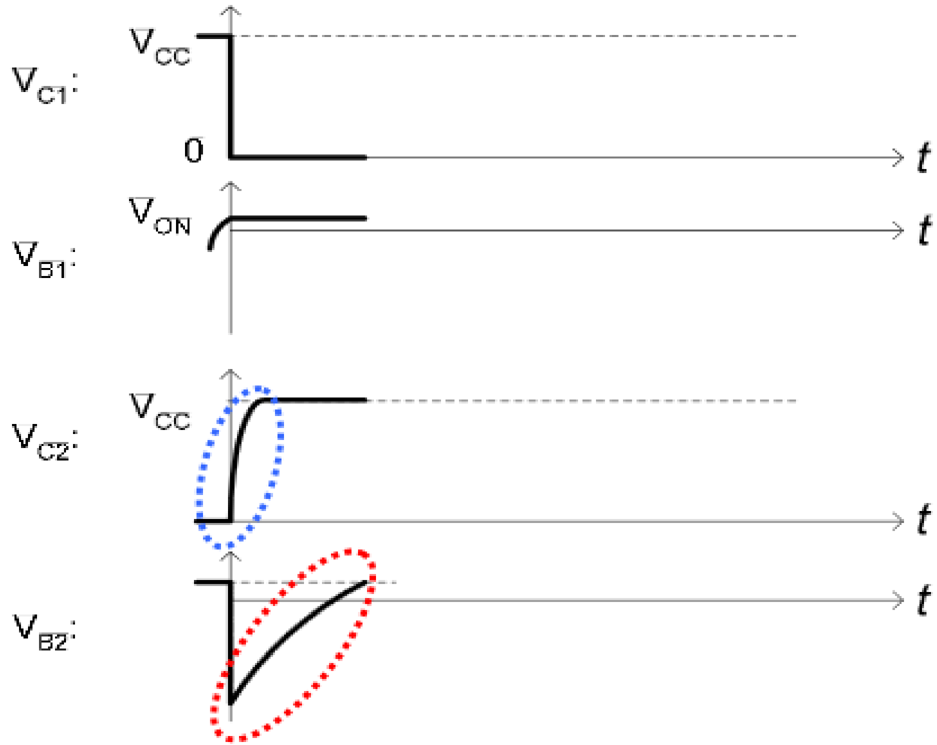
- As C_1's voltage cannot change instantaneously, V_{B2} drops by V_{CC}.

Operation

Astable Multivibrators

State 1





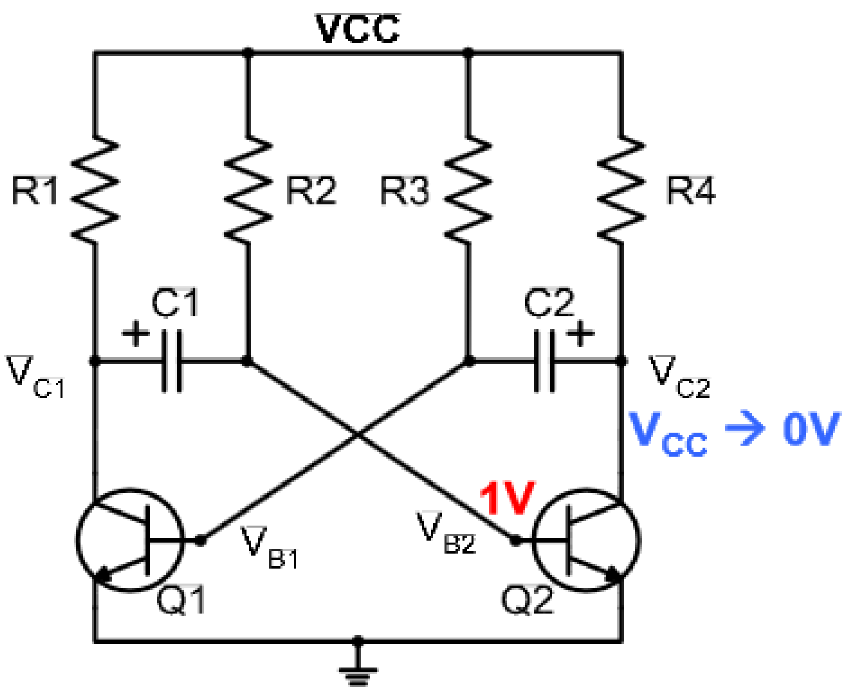
State 1 (cont'd):

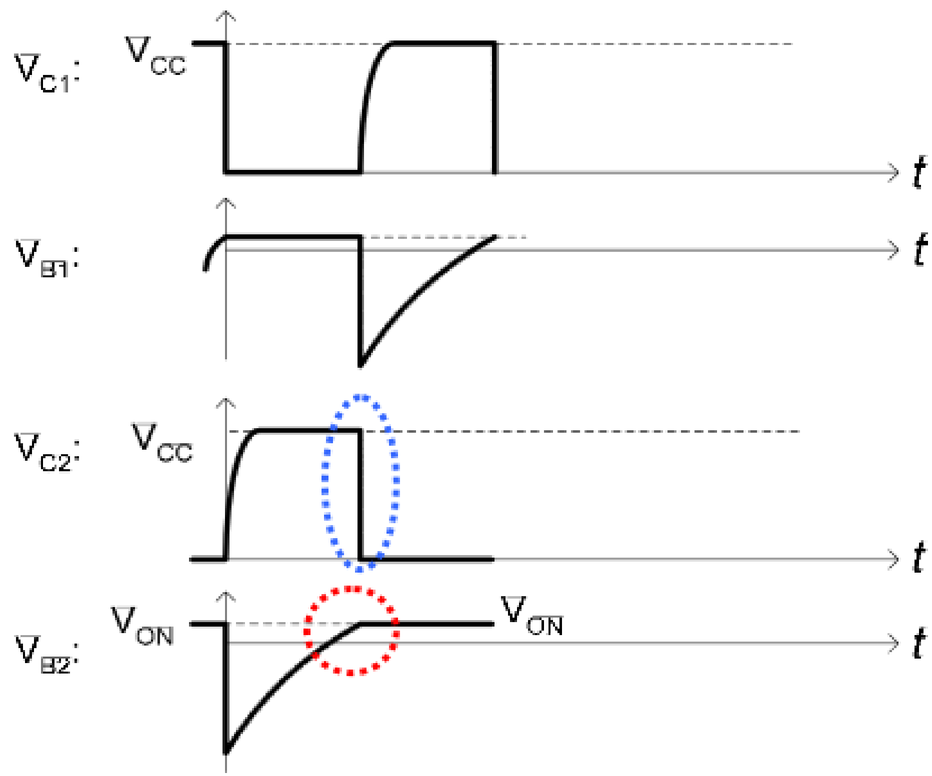
- Q_2 turns off and V_{C2} charges up through R_4 to V_{CC} (speed set by the time constant R_4C_2).
- V_{B2} charges up through R_2 towards V_{CC} (speed set by R_2C_1, which is slower than the charging up speed of V_{C2}).

Operation

Astable Multivibrators

State 2





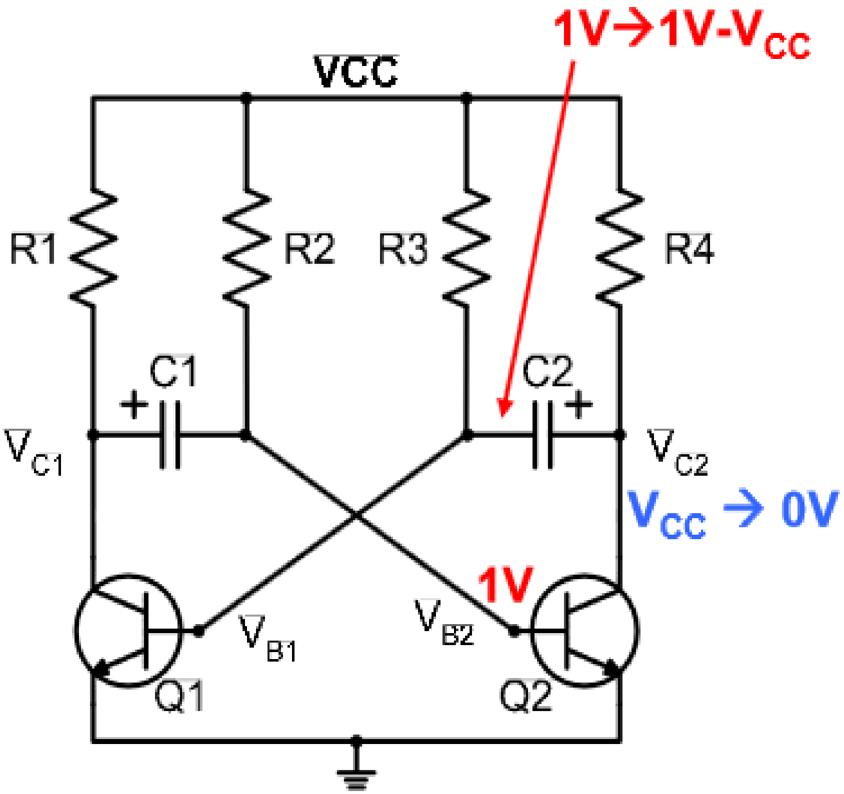
State 2:

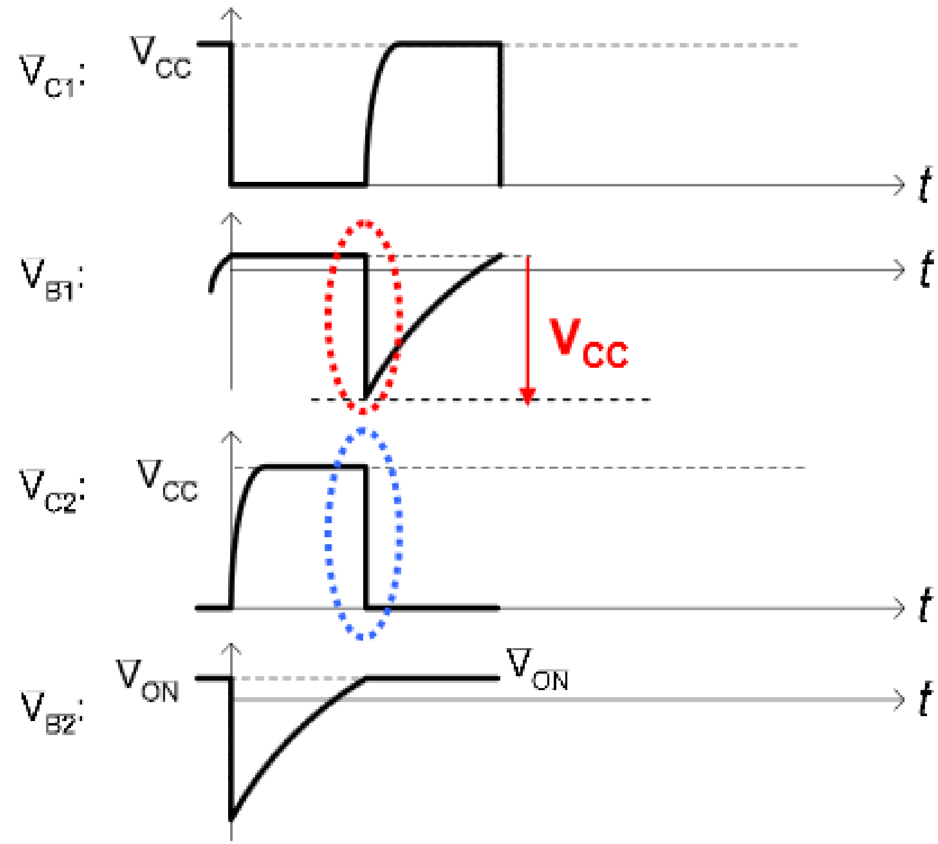
- When V_{B2} reaches V_{ON}, Q_2 turns on and pulls V_{C2} from V_{CC} to 0V.
- V_{B2} remains at V_{ON}.

Operation

Astable Multivibrators

State 2





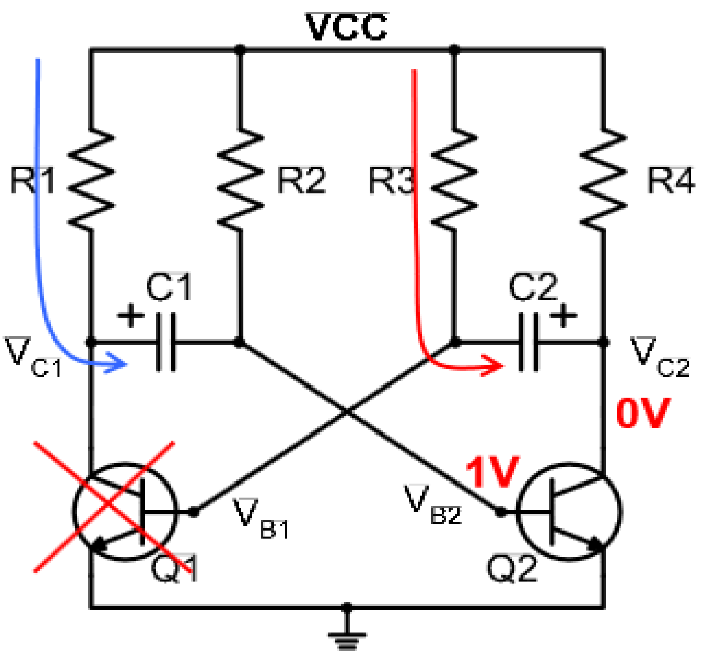
State 2 (cont'd):

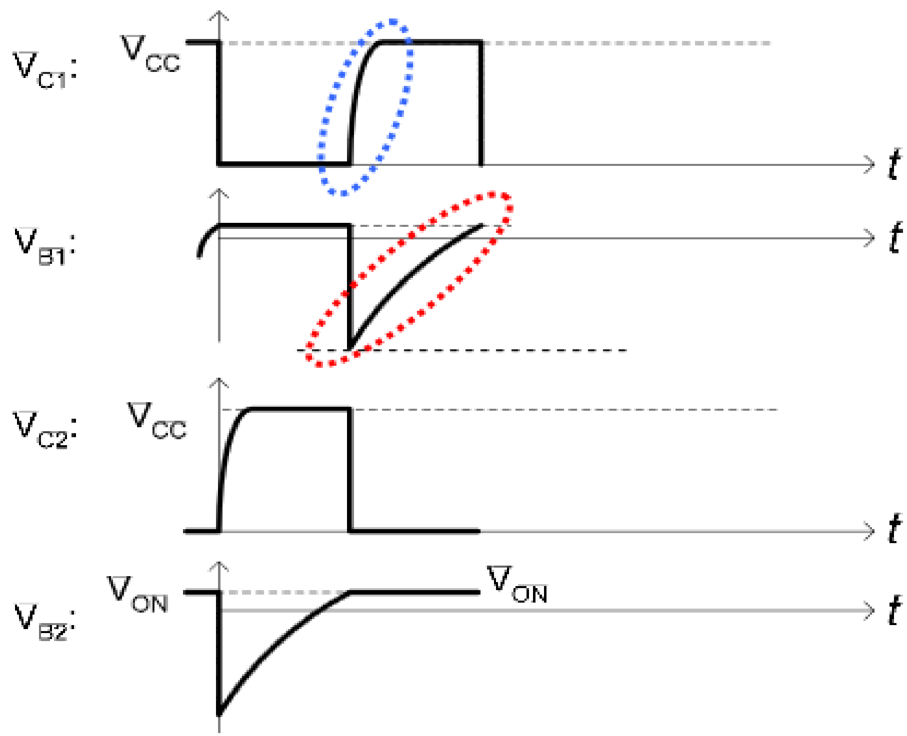
- As C_2's voltage cannot change instantaneously, V_{B1} drops by V_{CC}.

Operation

Astable Multivibrators

State 2





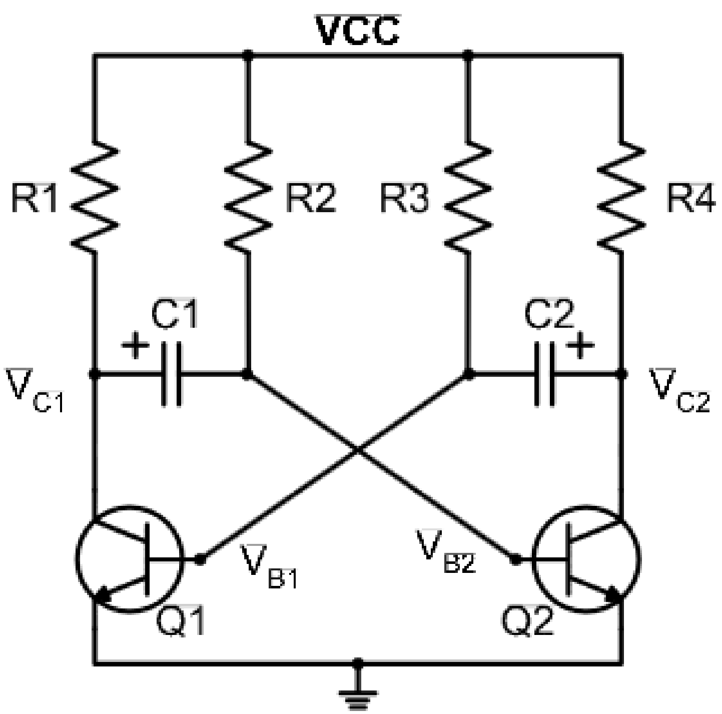
State 2 (cont'd):

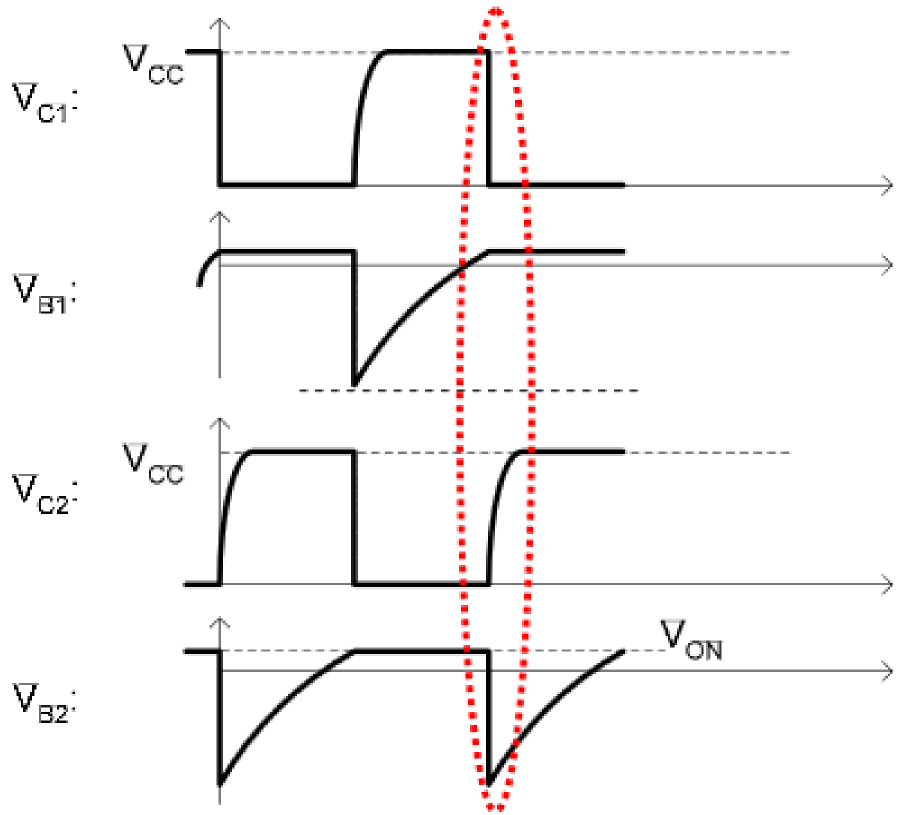
- Q_1 turns off and V_{C1} charges up through R_1 to V_{CC}, at a rate set by R_1C_1.
- V_{B2} charges up through R_3 towards V_{CC}, at a rate set by R_3C_2, which is slower.

Operation

Astable Multivibrators

State 2





Back to state 1:

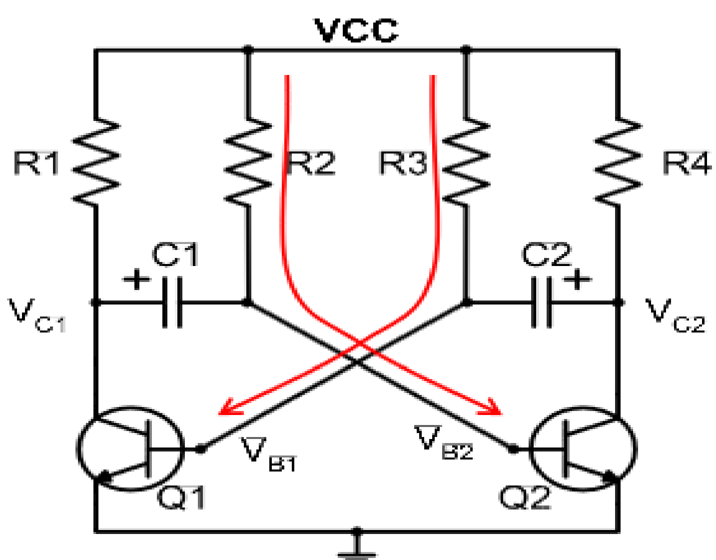
- When V_{B1} reaches Von, the circuit enters state 1 again, and the process repeats.

Operation

Astable Multivibrators

Initial Power-Up

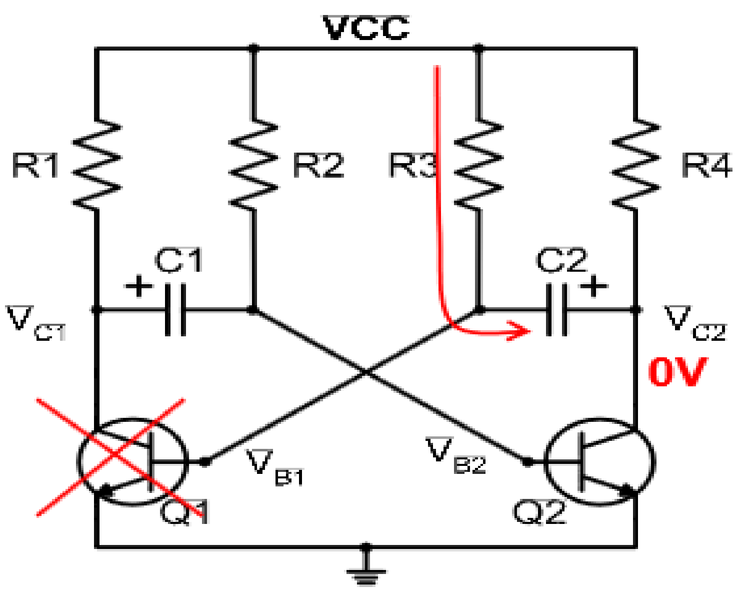
- When the circuit is first powered up, neither transistor is ON.
- Parasitic capacitors between B and E of Q_1 and Q_2 are charged up towards V_{CC} through R_2 and R_3. Both V_{B1} and V_{B2} rise.
- Inevitable slight asymmetries will mean that one of the transistors is first to switch on. This will quickly put the circuit into one of the above states, and oscillation will ensue.

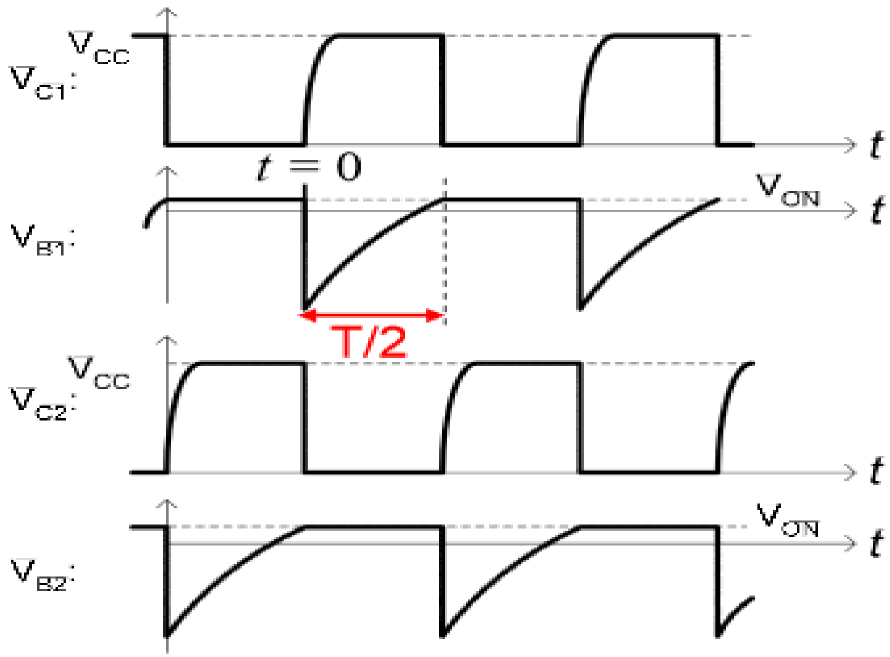


Operation

Astable Multivibrators

Multivibrator Frequency





$$v_{B1} = (V_{ON} - V_{CC}) + (2V_{CC} - V_{on})(1 - e^{-t/R_3C_2})$$

$$\approx -V_{CC} + 2V_{CC}(1 - e^{-t/R_3C_2}) \qquad \text{for } V_{ON} << V_{CC}$$

At t = T/2, $v_{B1}=V_{ON}$: $\quad V_{ON} = -V_{CC} + 2V_{CC}(1 - e^{-T/2R_3C_2})$

Operation

Astable Multivibrators

Multivibrator Frequency

$$V_{ON} = -V_{CC} + 2V_{CC}(1 - e^{-T/2R_3C_2})$$

$$\therefore V_{CC} \approx 2V_{CC}(1 - e^{-T/2R_3C_2}) \quad \text{for } V_{ON} << V_{CC}$$

$$\therefore 1 = 2(1 - e^{-T/2R_3C_2})$$

$$\therefore e^{-T/2R_3C_2} = 0.5$$

$$\therefore -\frac{T}{2R_3C_2} = -\ln 2$$

$$\boxed{\therefore T = 2(\ln 2)R_3C_2}$$

or $$\boxed{f = \frac{1}{2(\ln 2)R_3C_2}}$$

For the special case where

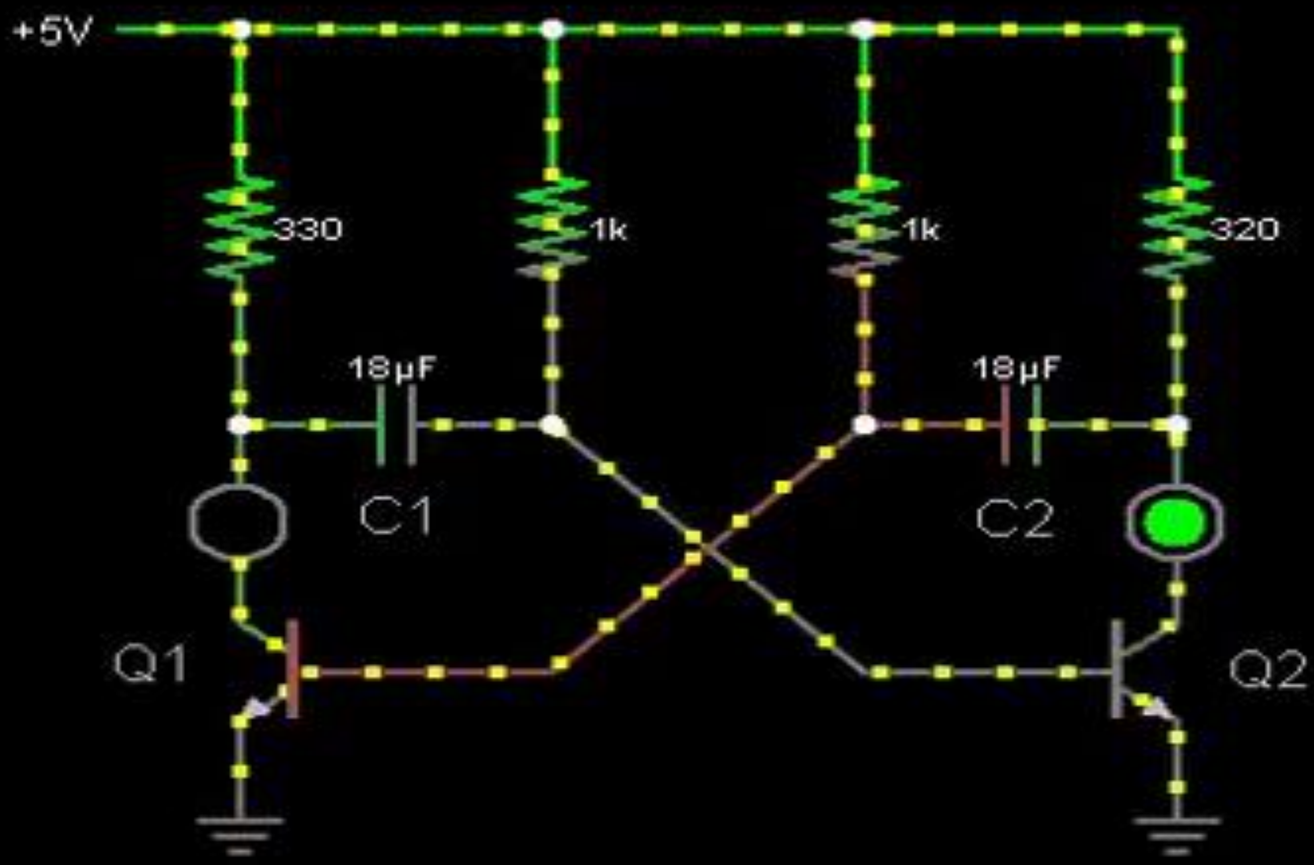
$$t_1 = t_2 \text{ (50\% duty cycle)}$$

$$R_2 = R_3$$

$$C_1 = C_2$$

$$f = \frac{1}{T} = \frac{1}{\ln(2) \cdot 2RC} \approx \frac{0.72}{RC}$$

Astable Multivibrators

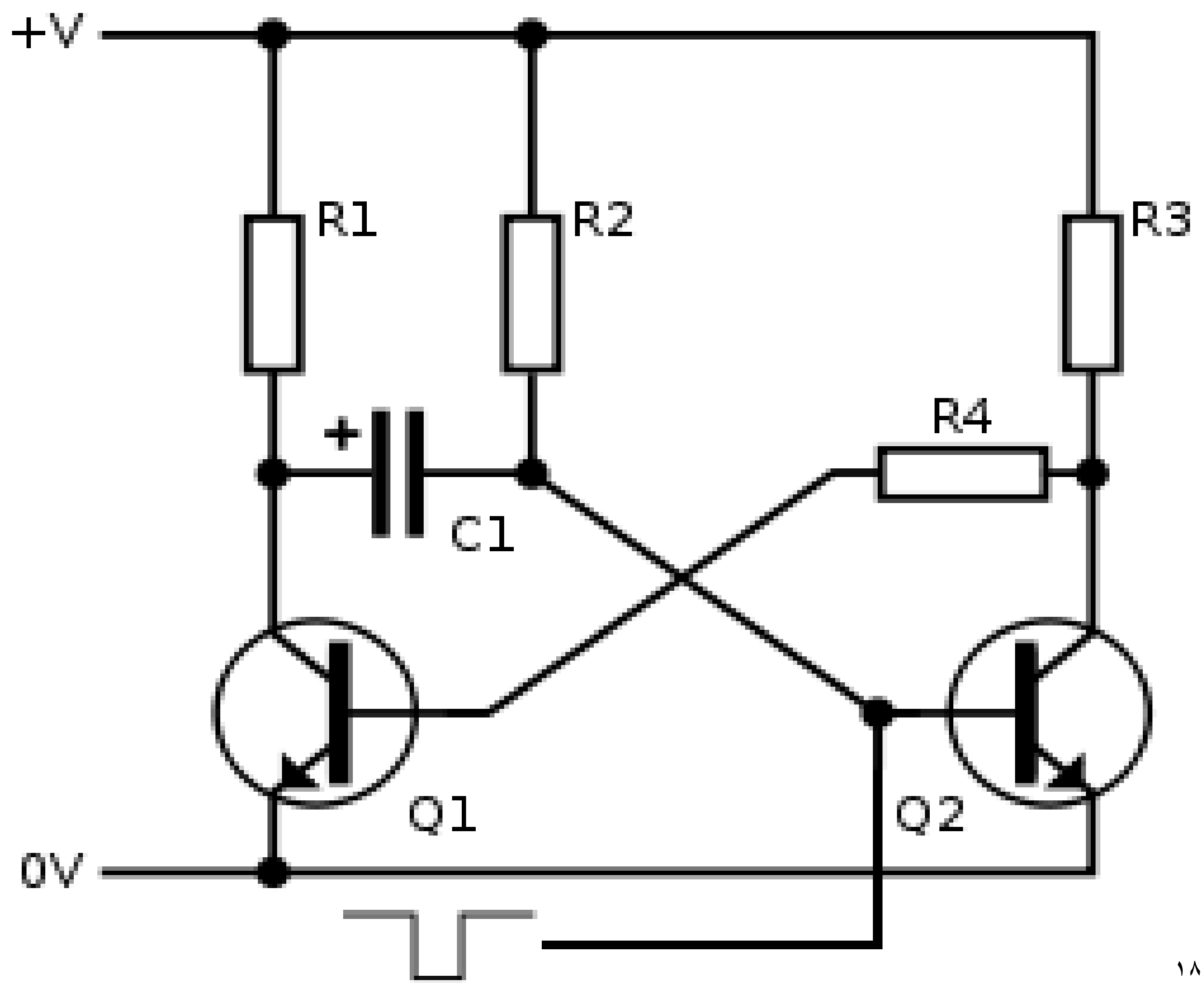


The monostable multivibrators are used as timers, delay circuits, gated circuits etc.

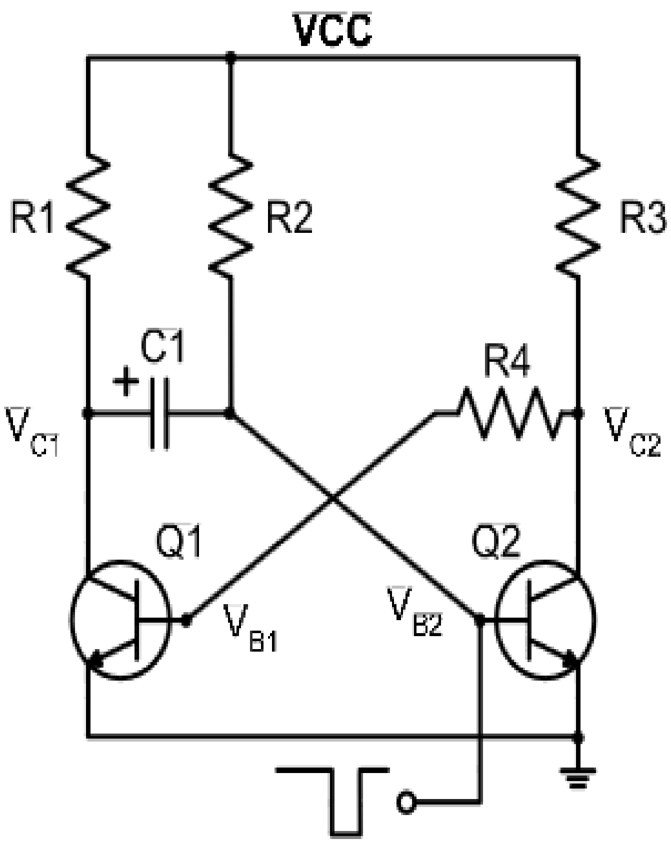
Monostable Multivibrators

is a square- or rectangular-wave generator with just one stable condition

Capacitive path between V_{C2} and V_{B1} removed.



Monostable Multivibrators



- Stable for one state (state 2 here)
  - Q_1 OFF and Q_2 ON
  - V_{C1} High, V_{C2} Low
- When V_{B2} is momentarily pulled to ground by an external signal
  - V_{C2} rises to V_{CC}
  - Q_1 turns on
  - V_{C1} pulled down to 0V
  - Enter state 1 temporarily
- When the external signal goes high
  - V_{B2} charges up to V_{CC} through R_2
  - After a certain time T, V_{B2}=V_{ON}, Q_2 turns on
  - V_{C2} pulled to 0V, Q_1 turns off
  - Enters state 2 and remains there
- Can be used as a timer

Monostable Multivibrators

The monostable multivibrator is basically used for pulse stretching. It is used in computer logic systems and communication navigation equipment.

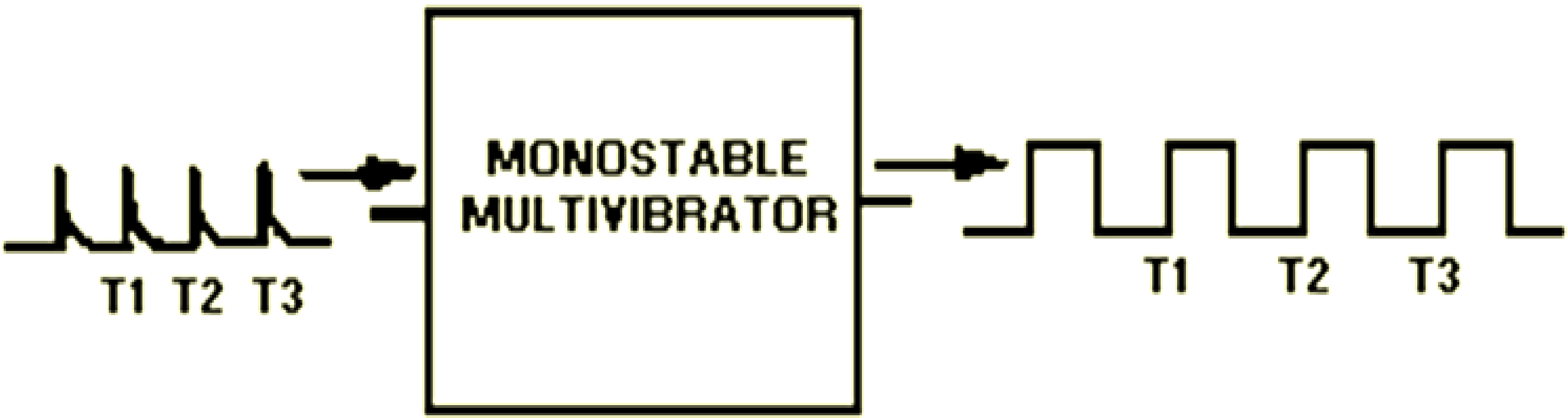


Figure 3.2: Monostable multivibrator block diagram.

THANK YOU

Dr. Mohamed Salah

QUIZ

Multiple Choice Questions

(1) Gain bandwidth product of an amplifier after inclusion of negative feed back

(a) decreases

(b) increases

(c) remains the same

(2) The voltage gain of an amplifier is 100. A negative feedback of 4% will reduce the gain to

a) 4 (b) 20 (c) 25 (d) 99.9

QUIZ

Multiple Choice Questions

(3) The most suitable oscillator circuit for 1 MHz frequency is

(a) Hartley oscillator
(b) Weinbridge oscillator
(c) phase-shift oscillator

(4) In Wien Bridge Oscillator, The output resistance of the amplifier must be ……….. so that the effect of external loading is minimized.

(a) High (b) low (c) triple

QUIZ

For the Phase shift oscillator, determine the Oscillation criterion if:

$$R_1 = R_2 = 2R$$
$$C_1 = C_2 = C_3 = 4C$$